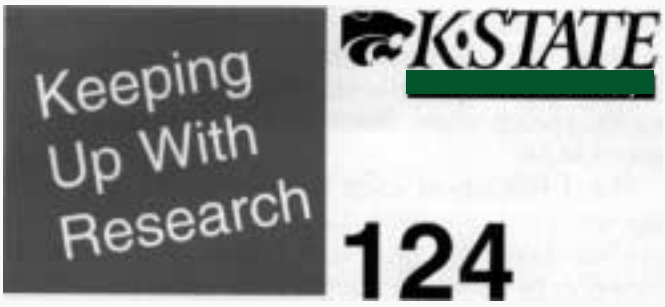

PREHARVEST SPROUTING OF HARD RED AND HARD WHITE WHEATS IN KANSAS

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Wheat in Kansas usually ripens under warm, dry conditions that favor development of excellent grain for bread making. However, the ripe grain can sprout in the spike when moist conditions delay harvest and promote germination. Persistent rain, heavy dew, and high humidity that stimulate preharvest sprouting are most common in eastern Kansas and least common in western Kansas. In central Kansas, moist conditions caused sprouting in 1979, 1989, 1993, and 1999.

Moisture swells wheat kernels and activates enzymes that break down proteins, starches, lipids, and other constituents in the endosperm. Flour milled from the endosperm of sprouted wheat produces bread that is porous and sticky and has a low loaf volume. The grain has little value to the milling and baking industries and is discounted heavily. More than 4% damaged kernels-including sprouted kernels-causes grain to be rated Grade 3 or lower and unacceptable for bread making. Grain that is slightly sprouted might be blended with sound grain for making flour, but grain that is severely sprouted usually is used for livestock feed.

Ripe grain is dormant and must pass through a period of afterripening before it can germinate, even under favorable conditions. The length of the afterripening period is highly variable, ranging from a few days in some varieties to a month or longer in others. Differences in the length of the afterripening period, or dormancy, greatly affect susceptibility of wheat varieties to preharvest sprouting. Most hard red win-

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ter wheat varieties have a long dormancy and are resistant to preharvest sprouting. Most hard white wheat varieties, in contrast, have little dormancy and quickly sprout when moisture and temperature are favorable.

The 1999 wheat crop in many areas of Kansas was subjected to repeated rains after it ripened. The wet, humid conditions slowed harvest and stimulated sprouting of some varieties. Preharvest sprouting of several new varieties of hard white wheat was of particular concern because of their susceptibility to the problem. The objectives of this research were to (1) determine the prevalence of preharvest sprouting of wheat under the severe conditions of 1999 and (2) identify differences in susceptibility to preharvest sprouting among several popular varieties of hard red winter wheat and new varieties of hard white wheat.

Procedures

Wheat performance tests evaluate adaptation, yield, and other traits of popular varieties and new experimental lines throughout Kansas. The tests use recommended production practices for each area, and the grain is harvested when local growers cut their crops. The plots are arranged in randomized complete block designs with four replications at all locations.

Grain samples were obtained from 10 varieties (six hard red and four hard white) whenever they were present at nine dryland locations of the wheat performance tests during 1999. Test weight of the grain was measured with a Dickey-John GAC II Grain Analyzer Computer as the plots were harvested. Approximately 100 grams of dry grain were collected from each plot for other measurements.

The percentage of sprouted kernels was determined using the Federal Grain Inspection Service criterion of "kernels with the germ end broken open from germination and showing sprouts or from which the sprouts have been broken off." Four students were instructed in the criterion, and each measured the percentage of sprouting in standard 15-gram subsamples of one replication of the samples. The mean kernel weight was measured by counting and weighing the same subsamples.

The remainder of each sample, approximately 85 grams, was ground through a l00-mesh sieve with a Udy Cyclone Sample Mill. The falling number, a standard unit for the degree of sprouting of wheat, was determined with a Perten Model 1800 apparatus by the procedure of the American Association of Cereal Chemists. The method measures the time in seconds for a plunger to fall through the gelatinized starch in a slurry of the ground grain. Grain that is sprouted severely has a low falling number, because high levels of a-amylase enzyme induced by germination rapidly hydrolyze the starch during the procedure. Sound, nonsprouted grain contains less a-amylase enzyme, which prolongs the time to degrade the gelatinized starch, and has a high falling number. The minimum falling number of grain for making bread is about 300 seconds.

Data were analyzed by standard general linear model procedures. Means were compared by Fisher's protected least significant differences ($P = 0.05$) and relationships among the data were calculated by Pearson (phenotypic) rank correlations.

Results

Percentages of sprouted kernels were low for most of the red wheat varieties at most locations (Table 1). Only Karl 92 sprouted significantly, with high levels of damaged kernels at Hesston and Hutchinson. Its pedigree contains the variety Parker, which previous research found to be moderately susceptible to preharvest sprouting. Sprouting percentages of the other varieties were statistically insignificant at all locations.

The white wheat varieties, with one exception, had considerably higher percentages of sprouted kernels than the red wheat varieties (Table 1). Oro Blanco, which appeared to be as resistant as some of the red wheat varieties, sprouted significantly only at Hesston. However, it was not tested at eastern locations where conditions were more favorable for sprouting. Betty and Heyne sprouted significantly at Powhattan, Manhattan, Parsons, Hesston, Hutchinson, and Hays, and Trego sprouted significantly at Manhattan, Parsons, and Hesston. At those locations, sprouting was often severe enough to lower the quality rating of the white wheat varieties to Grade 5 (10.1 to 15% damaged kernels) or Sample Grade (over 15% damaged kernels).

The falling numbers of most red wheat varieties were high at all locations (Table 2). Only Karl 92, the most susceptible variety, had values significantly below the 300-second threshold in several trials. Oro Blanco, which had low percentages of sprouted kernels at locations where it was tested, also had relatively high falling numbers that were similar to those for some of the red varieties. Heyne and Trego had values significantly below 300 seconds at five locations, and Betty had low values at six locations. Falling numbers and sprouting percentages of all samples were highly negatively correlated ($r = -0.7299$, $P<0.0001$).

Grain test weights of most varieties were high at all locations except Manhattan and Parsons (Table 3).

However, little difference occurred among varieties at any location. Values were low for Betty at Manhattan, TAM 107 at Hesston, and Heyne at Colby but were otherwise very similar. Test weights had a highly negative phenotypic correlation with sprouting percentages ($r = -0.2761$, $P<0.0001$) and a highly positive phenotypic correlation with falling number values ($r = 0.3080$, $P<0.0001$).

Kernel weights also were very similar at all except two locations (Table 4). Values for most varieties were high at Parsons and low at Powhattan. Kernel weights were low for Jagger and Oro Blanco at two locations each, for TAM 107 at Hesston, for Betty at Powhattan and Garden City, and for Heyne at Colby and Garden City. Kernel weights were not correlated significantly with any of the other traits, which suggested that sprouting reduced test weights by causing the grain to swell instead of losing dry matter.

Discussion

Conditions that favor preharvest sprouting of wheat occur with some frequency in Kansas. However, sprouting is not considered to be a serious problem in the state. As shown by our results, most varieties of hard red winter wheat have excellent resistance and rarely sprout even when conditions are favorable. Because hard red winter wheat is the predominate class, extensive sprouting is infrequent. However, the resistance in hard red winter wheat might be inadequate when conditions are particularly favorable for sprouting. In 1989, for instance, preharvest sprouting was so widespread in central and southcentral Kansas that growers were concerned about the availability of seed to plant the next year's crop.

Severe sprouting of several of the hard white wheat varieties in this survey is cause for concern. It suggests that increasing the acreage of these varieties will increase the frequency, area, and severity of sprouted wheat in the state during some years. Susceptible varieties are likely to sprout when conditions are moist, as in 1999, but resistant red wheat varieties do not sprout. Areas in which susceptible white wheat varieties replace red wheat varieties likely will experience more sprouting in the years ahead. When sprouting does occur, its effect on the quality of susceptible varieties for bread making will be more deleterious. Whereas red wheat varieties might sprout slightly and drop a grade or two in quality, susceptible white wheat varieties would suffer a greater percentage of sprouted kernels, a lower falling number, and a greater decline in quality rating.

Preharvest sprouting of white wheat would affect many sectors of the industry. Growers would receive

Table 1. Percentage sprouted kernels in grain of 10 varieties from nine locations of the 1999 Kansas Wheat Performance Tests.

Class and variety	Sprouted kernels (%)								
	Powhattan	Manhattan	Parsons	Belleville	Hesston	Hutchinson	Hays	Colby	Garden City
Hard Red									
Jagger	1.8	1.6	1.4	5.3	2.3	0.7	2.5	0.5	0.1
2137	2.5	0.6	1.2	0.3	1.1	2.4	0.3	0.6	0.9
TAM 107	2.1	0.1	1.0	0.4	4.2	0.5	0.2	1.8	0.2
Karl 92	1.0	3.7	1.4	0.8	11.9	8.2	1.6	0.9	0.2
2174	0.9	0.3	2.1	0.2	1.4	0.4	0.3	0.4	0.1
Dominator	–	1.2	–	0.2	6.7	1.1	0.4	1.6	–
Hard White									
Oro Blanco	–	–	–	0.2	12.6	5.6	2.2	0.4	0.2
Betty	14.1	16.3	54.4	1.1	26.2	22.5	8.2	0.9	0.3
Heyne	8.9	15.2	39.0	1.0	18.3	14.0	12.9	2.5	0.7
Trego	4.3	13.7	29.6	4.5	15.6	3.6	2.3	0.6	0.5
LSD (0.05)	6.3	5.9	8.2	NS	10.1	6.1	7.7	NS	NS
CV (%)	99	71	34	197	64	63	157	199	138

Table 2. Falling number of grain of 10 varieties from nine locations of the 1999 Kansas Wheat Performance Test

Class and variety	Falling number (set)								
	Powhattan	Manhattan	Parsons	Belleville	Hesston	Hutchinson	Hays	Colby	Garden City
Hard Red									
Jagger	344	326	386	333	298	306	400	305	389
2137	350	347	329	373	352	339	404	358	362
TAM 107	313	332	334	351	325	366	388	264	389
Karl 92	330	202	262	363	190	201	355	354	392
2174	294	318	282	316	295	333	370	362	364
Dominator	–	279		365	272	341	419	358	–
Hard White									
Oro Blanco	–	–		370	157	233	328	319	410
Betty	229	156	69	305	94	119	243	351	336
Heyne	238	146	82	320	122	149	277	345	364
Trego	294	196	85	261	116	217	291	296	360
LSD (0.05)	30	45	43	28	44	40	48	39	NS
CV (%)	7	13	14	6	14	11	10	8	8

Table 3. Test weight of grain of 10 varieties from eight locations of the 1999 Kansas Wheat Performance Tests

Class and variety	Test weight (lbs/bu)							
	Manhattan	Parsons	Belleville	Hesston	Hutchinson	Hays	Colby	Garden City
Hard Red								
Jagger	55	56	57	58	58	59	58	57
2137	55	56	58	59	59	60	58	57
TAM 107	55	54	58	55	58	58	58	58
Karl 92	55	55	58	58	59	60	59	59
2174	56	57	58	60	60	61	60	59
Dominator	57	—	58	60	60	61	58	—
Hard White								
Oro Blanco	—	—	58	58	58	58	59	57
Betty	51	55	58	58	58	60	58	58
Heyne	55	54	57	58	59	59	56	57
Trego	57	56	59	59	60	61	59	60
LSD (0.05)	2	1	1	1	1	NS	1	1
CV (%)	2	2	1	1	1	3	1	1

Table 4. Kernel weight of grain of 10 varieties from nine locations of the 1999 Kansas Wheat Performance Tests.

Class and variety	Kernel weight (mg/kernel)								
	Powhattan	Manhattan	Parsons	Belleville	Hesston	Hutchinson	Hays	Colby	Garden City
Hard Red									
Jagger	22	24	33	26	25	27	28	27	25
2137	24	27	34	30	29	30	31	29	27
TAM 107	24	32	32	32	20	32	33	33	29
Karl 92	26	29	33	30	28	29	30	28	27
2174	25	29	33	30	28	29	28	27	26
Dominator	—	25	—	27	28	27	29	27	—
Hard White									
Oro Blanco	—	—	—	27	24	24	27	28	23
Betty	22	25	30	29	27	26	27	27	25
Heyne	24	25	31	29	29	27	29	26	25
Trego	23	31	33	31	28	32	31	31	28
LSD (0.05)	2	2	2	2	2	2	1	1	2
CV (%)	5	6	5	5	5	5	3	2	4

a low price for the grain because of the large discount. The milling and baking industries could not use the grain, if it made unacceptable products. Exporters could not ship the grain, if it did not meet grade specifications. Seed growers could not certify the grain for seed, if germination and test weight were low.

The results suggest several ways in which preharvest sprouting of white wheat might be reduced. The relatively low sprouting percentages and high falling numbers of Oro Blanco and Trego in some of the tests demonstrate that resistance to preharvest sprouting can be incorporated into white wheat varieties by breeding. Breeders should consider placing greater emphasis on this genetic trait when developing improved varieties of white wheat for Kansas growers. Genetic resistance is especially important for varieties in eastern and central Kansas because of the higher incidence of conditions that promote sprouting.

Production of white wheat might be emphasized initially in western Kansas, where conditions are less favorable for sprouting, until resistant varieties become available for central and eastern parts of the state. Highway 81 has been recommended as a possible dividing line. However, sprouting of the white wheats in 1999 in Hesston (Harvey County), Hutchinson (Reno County), and Hays (Ellis County) suggests that the problem can be expected in major wheat areas immediately west of Highway 81 during severe years. Therefore, the area west of Highway 281 or 183, where conditions that promote sprouting are less likely to occur, might be more appropriate for producing susceptible varieties.

Growers can reduce the problem of preharvest sprouting of white wheat by promptly harvesting the crop when it is ripe. The low level of dormancy in most varieties rapidly dissipates after the crop matures, making the grain highly susceptible to sprouting. Prompt harvest will reduce the likelihood of rain causing the crop to sprout.

White wheat is highly adapted and has many advantages over red wheat, e.g., flour yield, taste, and marketability. Production of this new crop in Kansas can benefit the entire industry. The percentage of sprouted kernels will be as low and the falling number as high for white wheat as for red wheat in all parts of the state in most years. However, conditions that favor preharvest sprouting of white wheat will occur in the future as they have in the past, and the problem must be recognized. Varieties that resist sprouting should be developed, and growers should consider the potential for sprouting when deciding to produce this crop.

Conclusions

- Preharvest sprouting of wheat is a potential problem in all parts of Kansas.
- Conditions that favor preharvest sprouting of wheat occur more frequently in eastern and central areas than in western Kansas.
- Most white wheat varieties are more susceptible to preharvest sprouting than red wheat varieties.
- The frequency of preharvest sprouting likely will grow as the acreage of white wheat increases.
- The problem of preharvest sprouting of white wheat might be reduced by developing resistant varieties, carefully considering the region for production, and promptly harvesting the crop when it is ripe.

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